

REMARKS

Claims 1, 5, 6, and 10 are pending in this Application. Claims 1 and 6 have been amended. Claims 2 and 7 have been cancelled.

In the Office Action, the disclosure was objected to because of a typographical error in paragraph 0049. This paragraph has been amended to correct the error. Applicant believes this amendment is fully responsive to the Examiner's concerns.

Claims 1, 2, 5-7, and 10 were rejected under 35 U.S.C. § 103 (a) as being unpatentable over the Applicant's admitted prior art at paragraphs 48-54 of the present application ("the APA"). Claims 1, 2, 5 through 7, and 10 were rejected under 35 U.S.C. § 103 (a) as being unpatentable over the APA as applied to claims 1, 2, 5-7 and 10 *supra*, and further in combination with Japanese Patent Document JP04-299591 (Kumiko). These rejections are respectfully traversed. Applicant hereby requests reconsideration and allowance of the claims in view of the following arguments.

Independent claims 1 and 6 have been amended to recite that the second coating layer is thicker than the first coating layer. Claims 1 and 6 have also been amended to recite that the first coating layer is made of material selected from a group of silicon nitride, silicon oxide, silicon oxi-nitride and aluminum oxide, formed by an ion-assisted evaporation technique. These claims have been further amended to recite that a total thickness of the first layer and the second layer is less than a quarter of the recited predetermined wavelength. These amendments are fully supported, for example, at paragraphs 0044 and 0055 of the present application, and in original dependent claims 2 and 7, which have consequently been cancelled. No new matter has been added. Thus, the invention of amended claims 2 and 6 requires that the total thickness of the two coating layers is less than a quarter of the emission wavelength of the device, and further

requires that the second film is thinner than the first film. This feature of the claimed invention reduces the stress applied to the facet of the semiconductor material, as explained in greater detail hereinbelow, thereby enhancing the long-term reliability of the claimed device.

Regarding the rejection of amended independent claims 1 and 6 based on the APA alone, it is contended in the Office Action that it would have been obvious to switch the materials of the first and second layers of the APA to yield the invention of claims 2 and 6. Applicant disagrees. The APA discussed at paragraph 0049 of the present application teaches that its goal is to form an antireflective (AR) film on the facet of a laser diode that exhibits a wide bandwidth and low reflectivity. For example, its AR film made of $\text{TiO}_2/\text{SiO}_2$ exhibits a reflectivity of 5.3×10^{-6} as a minimum reflectivity, and a bandwidth of 143 nm where the reflectivity is less than 10^{-3} . The APA points out this is superior to AR films made of a single material, which exhibit bandwidths from 90 to 100 nm at most.

However, when an AR film comprising two materials is formed, such as the APA $\text{TiO}_2/\text{Al}_2\text{O}_3$ “higher/lower” refractive index film formed by an ion-assisted evaporation technique, damage to the facet of the semiconductor material typically results, disadvantageously degrading the leakage current of the device. This occurs because a TiO_2 film of good quality can only be obtained by increasing the accelerating voltage for the ion beams, which damages the semiconductor material. The Applicant addressed this problem by forming an Al_2O_3 film with a lower refractive index first (i.e., directly on the semiconductor facet), using a relatively low accelerating voltage, and forming a TiO_2 film with a higher refractive index on the Al_2O_3 film, thereby creating a “lower/higher” refractive index AR film having both lower reflectivity and a reduced leakage current, because there is no damage to the semiconductor.

Although the claimed lower/higher refractive index AR film of the present invention results in less leakage current, it exhibits a smaller bandwidth. For example, as shown in paragraph 0052 of the present application, the bandwidth of a claimed AR film comprising Al_2O_3 and TiO_2 is about 80 nm at most, where the reflectivity R is smaller than 10^{-3} . This is a much narrower bandwidth than the prior art AR film made of a single material.

In summary, the APA has the stated goal of obtaining low reflectivity from a two-material AR film with a higher/lower refractive index, that also exhibits a wavelength bandwidth wider than that obtained by the prior art AR film comprising a single material. In contrast, the claimed AR film exhibits a *narrower* bandwidth than that of the conventional single-material film. Therefore, one skilled in the art would not have a reason to modify the APA to yield the claimed invention by switching the order of the materials in its AR film to the recited lower/higher refractive index. Looking at it another way, the APA teaches away from the claimed order of materials. It is well-established that if a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *See, MPEP §2143.01(V).*

Even assuming, *arguendo*, that it would have been obvious to switch the materials of the first and second layers of the APA, the prior art discussed in the application does not teach or even suggest that the total thickness of an antireflective (AR) film is less than a quarter of the emission wavelength of the light generated by the device, *and that the second film is thinner than the first film*, as required by these claims.

Specifically, the APA teaches obtaining an AR film comprising two materials that exhibits low reflectivity and a broad bandwidth. Such an AR may be realized by the APA by a combination of, for example, TiO_2 having a thickness of 121.4 nm as the first material and SiO_2

having a thickness of 189 nm as the second material, when the emission wavelength of the laser diode is 1550 nm. Another such example, wherein the second film is significantly thicker than the first film, is given at paragraph 0049 of the present application. The APA explicitly teaches that its second film is much thicker than its first film, contrary to the AR film of amended claims 2 and 6, where the second film is thinner than the first film. Since the APA teaches the exact opposite of the claimed order of film thicknesses, one skilled in the art would not have had a reason to modify the APA to yield the invention of amended claims 2 and 6.

Consequently, amended independent claims 2 and 6 are patentable over the APA, as are claims 5 and 10, which depend from claims 2 and 6, respectively.

Regarding the obviousness rejection of independent claims 2 and 6 based on the APA and Kumiko, the Kumiko reference discloses two types of two-layer AR films, one with a higher/lower refractive index, and another with a lower/higher refractive index. However, Kumiko does not disclose or even suggest the claimed materials specified for each of the first and second layers, despite contentions to the contrary in the Office Action. Specifically, Kumiko teaches a combined film of Y_2O_3/AlN , but not the claimed combination of Al_2O_3/TiO_2 . Kumiko further discloses using MgO , Al_2O_3 , and SiO_2 as the material having the lower refractive index, but not SiN , as claimed. Moreover, Kumiko teaches using TiO_2 as the higher refractive index material, but not T_2O_5 , as claimed. Still further, Kumiko mentions that SiN , which is recited in claims 2 and 6 as a material used for the first layer having a lower refractive index, can be used as a film having the higher refractive index. Applicant notes the claimed film configuration does not employ SiN as the recited second film having the higher refractive index. Thus, Kumiko arguably teaches away from the recited materials used for each of the first and second layers.

Kumiko is also teaches away from the recitation in amended claims 2 and 6 that the total thickness of the first and second layers is less than a quarter of the emission wavelength. Kumiko explicitly teaches that, whether a combination of higher/lower refractive index or lower/higher refractive index films are used, it is necessary for the total thickness to be *equal* to a quarter of the emission wavelength, to result in the desired anti-reflectivity. This thickness requirement is disadvantageous because the reflectivity of such a film drastically changes when the thickness of the second material varies only a few nanometers. In contrast, as illustrated in the table at paragraph 0055 of the present application, the film of the present invention is much thinner than a quarter of the emission wavelength, which places less stress on the facet of the semiconductor material, enhancing the long-term reliability of the device.

Thus, one skilled in the art would have no reason to combine the APA and Kumiko to yield the invention of amended claims 2 and 6, because Kumiko teaches away from several features of these claims. If one were to combine these two references, the result would probably be an AR film having a thickness equal to a quarter of the emission wavelength (not less than a quarter, as claimed), and two films made of different materials than those claimed.

Consequently, claims 2 and 6 are patentable, as are claims 5 and 10, which depend from claims 2 and 6, respectively.

Having fully responded to all matters raised in the Office Action, Applicant submits that all claims are in condition for allowance, an indication for which is respectfully solicited. If there are any outstanding issues that might be resolved by an interview or an Examiner's amendment, the Examiner is requested to call Applicant's attorney at the telephone number shown below.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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